Cosmic Closure: Relating the Ultimate Fate of Massive Stars and the Ultimate Fate of the Universe

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We give a brief overview of the status of core collapse supernova modeling, particularly as it pertains to predictions of neutrino signatures for the next galactic or near extragalactic supernova. We also consider the implications of neutrino mass for both the supernova mechanism and neutrino signature predictions.

1 Introduction

The possibility of connecting the ultimate fate of massive stars, i.e., their death through core collapse supernova explosions, and the ultimate fate of the Universe is an exciting one. Core collapse supernovae are powered by neutrinos. These astyrophysical events produce more than 10^{57} neutrinos per second, making them the most copious localized source of neutrinos in the Universe and an ideal laboratory for the exploration of neutrino physics. Moreover, given the prevalence of neutrinos in the Universe, owing to its early evolution, neutrino masses in the range $3 - 10$ eV would result in a significant neutrino contribution to the closure density and the Universe's ultimate fate. A nonzero neutrino mass also opens up the possibility of neutrino oscillations, which, as we will discuss, may have ramifications for the supernova mechanism and, as we will show, will certainly have ramifications for supernova neutrino signature predictions.

2 The Core Collapse Supernova Mechanism: A Status Report

Core collapse supernovae result when the iron core of a massive star becomes unstable late in the star's life, collapses gravitationally, at supernuclear densities becomes incompressible, rebounds, and generates a shock wave that ultimately propagates out through the core and the outer layers of the star to disrupt it in a core collapse supernova explosion. Unfortunately, because of dissociation and neutrino losses, the shock stalls to form an accretion shock.